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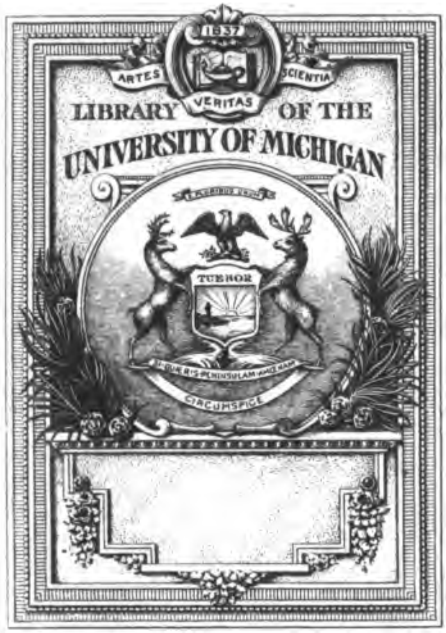
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PROTECTIVE LIGHTING

ILLUMINATION AS A MEANS OF DEFENSE OF PROPERTY

THE GENERAL PRINCIPLES AND PRACTICE OF PROTECTIVE LIGHTING OF INDUSTRIAL PLANTS, PUBLIC WORKS, ETC.

76

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Prepared for the United States Government by the Committee on War Service of the Illuminating Engineering Society, January, 1918

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WAR DEPARTMENT,
WASHINGTON, *May 3, 1918.*

The following pamphlet entitled "Protective Lighting" is published for the information of all concerned.

(062.1 A. G. O.)

BY ORDER OF THE SECRETARY OF WAR:

PEYTON C. MARCH,
Major General, Acting Chief of Staff.

OFFICIAL:
H. P. McCAIN,
The Adjutant General.

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PROTECTIVE LIGHTING.

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This work was begun at the request of the Secretary of War, and carried out by Hollis Godfrey Commissioner of Engineering of the Advisory Commission of the Council of National Defense.

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THE NECESSITY FOR GUARDING PROPERTY.

101. It is essential to the successful prosecution of the war that all property employed in war industries be guarded against attack designed to destroy the property or to interrupt operations. All property essential to the well-being of our communities must be guarded from attack designed to hamper activities, menace health, or weaken morale. Industrial plants, storage places, transportation systems, piers, waterworks, public utilities, etc., must be guarded effectively. Every man in charge of such property must consider himself responsible for its security to an even greater extent than is the police force, because of his greater knowledge of its special vulnerability.

THE PLACE OF ARTIFICIAL LIGHTING AMONG METHODS OF GUARDING PROPERTY.

102. Armed guards on fixed post and on patrol are able in the daytime to protect property very effectively. Night renders their protection less effective, because of inability to see. The night condition is further complicated by the fact that generally fewer persons are about and enemy agents have more opportunity to operate unobserved.

103. Most methods of destruction which alien enemies are likely to practice require a certain amount of time in application. Under cover of darkness the attack may be prepared at leisure. Darkness, therefore, is one of the greatest aids to the commission of such crime.

GENERAL CONSIDERATIONS.

104. *The function of protective lighting* is twofold—to dete from attempts at depredation and to insure apprehension when a menace does arise. While itself an essential means of defense, it must nevertheless be employed in conjunction with other measures, such as guards at fixed posts or patrols, fencing or other barriers about the protected area, alarm systems, etc.

105. *The extent to which lighting should be employed* varies, first, with the other protective provisions. The more liberally light is employed, the greater the reduction in the number of necessary guards. The more difficult the access to a property, the less the necessity for high intensities of illumination. Secondly, the amount of the lighting depends upon the importance and vulnerability of the properties. With the most vital, every means of protection should be provided generously. For those of secondary importance, less will suffice, or methods other than by the use of guards, and lighting may even be dispensed with.

106. *The problem in protective lighting* is to make every menace easily visible to the guard, whether it be at the boundaries of the property, about the yards, or within a building, and to do this by means of a system which is reliable and provides sufficiently against all emergencies.

107. *How we see.*—An object is revealed to the eye either because of the light falling upon it and reflected back, or because it is outlined as a shadow against a lighter background. In figure 1 the man is discernible by the first of these methods. In figure 2 the guard is able to see him in silhouette because he is between the guard and the bright fence. If everywhere about the property one of these conditions is obtained through a sufficient quantity of light, properly directed and diffused, guarding becomes simple.

The problem is exactly the reverse of camouflage, where it is desired to make objects invisible by blending them with their backgrounds through proper choice of color and other artifices. To see an object readily requires strong contrast between it and the background.

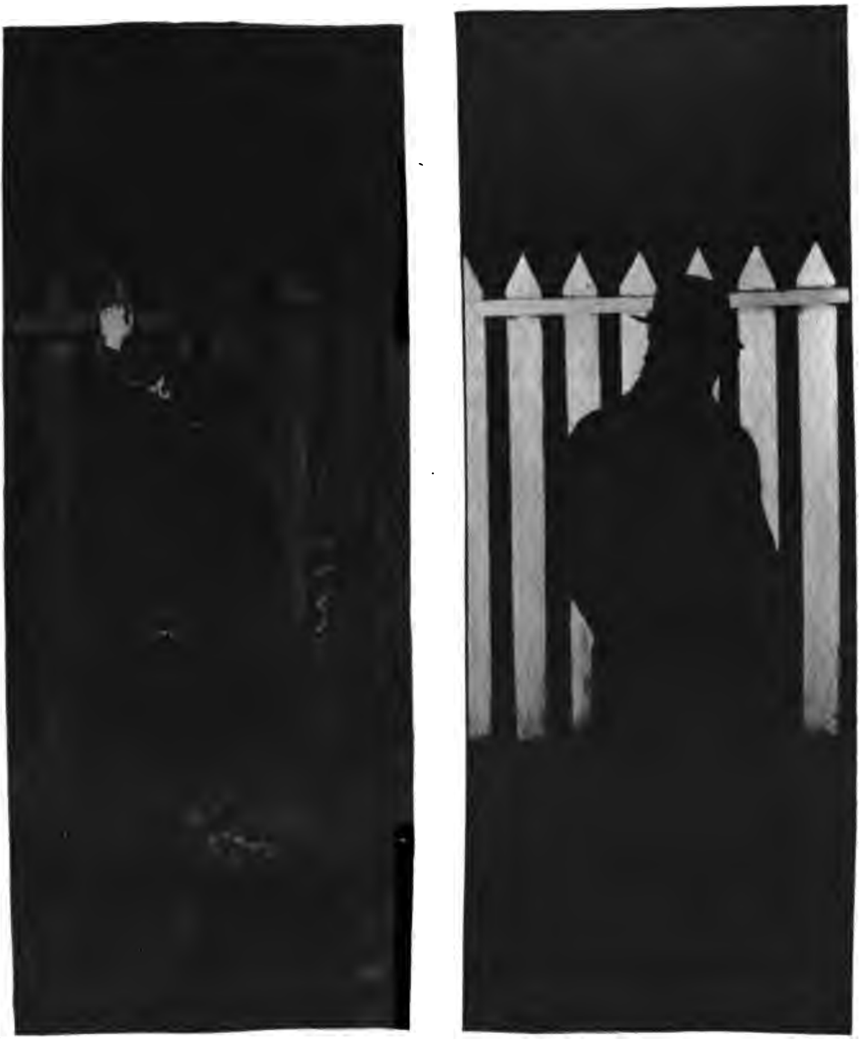

FIG. 1. FIG. 2.

Man revealed by incident light and by silhouetting.

Several factors affect the quantity of light required, chiefly the following:

108. A. *The reflection factor of the surfaces involved.*—This factor may vary from less than 5 per cent to as high as 75 per cent. A dark red brick wall reflects only 5 per cent of the light striking it; a light-green surface will return one-third; and white paint or whitewash about three-quarters. Dust and other factors will of course cause a reduction in this high percentage. Nevertheless the light painted or whitewashed surface will require but a fraction of the light necessary with the red brick.

109. B. *Atmospheric conditions.*—A light intensity that is ample in a clear atmosphere may fail to reveal an object through smoke, in a haze or fog. More light must therefore be provided than would be demanded under favorable conditions.

110. C. *General brightness of surroundings* and the adaptation of the eye. If all surrounding surfaces are always darker than the object viewed, it is visible at a relatively low intensity, but if, nearby, are unshaded lamps, bright windows or other areas, materially higher intensities must be employed, for the eye adapts itself to the highest brightness in the field of view. A considerable period elapses before the eye is adapted for keenest vision in dark surroundings. Hence, if the guard must pass from a lighted building or other bright area, he requires more light out of doors.

111. D. *Glare.*—If one tries to look at an object near a bright light source, he finds his ability to see the outlines in detail is greatly reduced. If the source is sufficiently bright and powerful, he experiences marked discomfort, and if the condition is long continued, even permanent injury to the eye may result. Glare is caused—

1. By excessive contrast in brightness. An unshaded lamp close to the object viewed may hide it completely, or at least require several times the intensity that would otherwise be employed; but the brightest incandescent filament viewed against the sky by day causes no glare. When the eye has been in darkness, even the moon rising over a mountain may be a source of glare.

2. By excessive quantity of light directed toward the eye. The eye once adapted to the moonlight experiences no further glare, but the sun, which has the same ratio of brightness to its surroundings, is intolerable. A large lamp, though inclosed in a large diffusing globe, causes far more glare than the small, though equally bright, candle flame.

3. By light entering the eye at a small angle from the line of vision. As this angle is increased, the effect is reduced.

112. The following methods may therefore be adopted to minimize the effect of glare:

A. Reduction in brightness contrast, by the use of diffusing globes on the sources, by the higher illumination of the background, or by both. Against a black sky the use of a diffusing globe will not greatly reduce the ratio of brightness.

B. Shielding the source from the eye by an opaque reflector or shade.

C. Obtaining a given amount of light from a larger number of less powerful lamps.

D. Mounting units high to increase the angle from the line of vision.

The methods of B and D are the ones most often effective and practicable in outdoor illumination.

113. *The practical application of these principles* of vision to the problem of protective lighting may be summarized thus:

A. Illuminate every point in the area to be guarded, or light sufficient surfaces so that it will be impossible for any menace to appear unless it be between the guard and one of these surfaces.

B. Make the lighted areas of as good light-reflecting quality as practicable.

C. Conceal all bright light sources from the eyes of the guard.

114. Each installation must be developed to meet the local conditions. To accomplish this most expeditiously, the assistance of someone who is experienced in the design of such installations should be obtained. In some cases the engineer in charge of the property is qualified to act. The local lighting company usually has some one on its staff who is acquainted with practice in this field, and whose assistance can be had. Manufacturers of lamps and equipment may often be consulted with advantage. The services of a competent consulting illuminating engineer will prove valuable where conditions permit his employment.

115. In any event to proceed with the solution of the problem requires complete data as to the dimensions and character of the property to be protected, the color or reflecting qualities of the surfaces, covering both buildings and intermediate areas, piles of material, and other obstructions. A plot plan with these data indicated is particularly valuable in determining a preliminary location for the units. The character of service available for supplying the lamps is an essential consideration in specifying the units. The general nature of the boundaries or the surroundings, particularly with reference to other lighting, must be known in order to provide the requisite intensities.

116. The illuminants available and most useful for protection are listed in the section on equipment, where they are classified as to source of supply, light output and distribution characteristics. It will be seen that the electric units are unique in that they are available in every type and permit any desired degree of control of the light. The gas units are especially important from the standpoint of insuring continuity of service; they frequently serve well as an auxiliary. In a given installation the question of availability of an electric or gas supply and the various equipments, must form a major consideration in order that protection may be afforded quickly.

117. The self-contained lighting units are needed for structures remote from the central supply, but they have an even wider application for property of especially vulnerable character or of special importance to provide against complete interruption of all centrally supplied units. These must be placed so as to be readily seized by the guards, foremen in the shops, etc., in an emergency.

118. In the section on lighting practice are given in detail instructions as to the use of these various equipments. Emphasis is placed on the use of such units as will protect the eyes of the guard and make vision most easy for him, and at the same time redirect the light so that it will be utilized most efficiently. The range of intensities specified is such as to provide for ordinary conditions of haze [1] and smoke in the atmosphere and the presence of some moderately bright sources such as windows, distant street lamps, etc., in the field of view.

119. Under the most favorable conditions somewhat less lighting will doubtless sometimes prove satisfactory. On the

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[1] Unfortunately protective lighting loses much of its effectiveness in a fog. The light will not penetrate a dense fog to a sufficiently great distance. Even if the light did penetrate, vision could not penetrate.

The use of yellow light in the case of the fog has been advocated. While claims in this connection have been advanced, it does not seem to have been demonstrated reliably that yellow light possesses large advantages. It is generally believed that in the case of a light fog there is some slight advantage possessed by yellow light over the usual light of illuminants, especially in the case of a searchlight or a flood light beam with the observer standing behind the lighting unit and looking along the beam. The advantage, however, is probably not sufficient to warrant any considerable expenditure to provide for the alternative of yellow light in such cases. Aside from any slight superiority which yellow light may possess for illuminating through fog, there remains the possibility of realizing some slight advantage by wearing yellow glasses when looking from behind a searchlight along the beam of light.

In the case of fog additional guarding precautions have to be taken. More guards have to be used. The patrol must be made more thorough. Mechanical or electrical alarm systems to reveal the presence of an intruder may in some cases be utilized. Also, the sweep of a searchlight in the fog may serve somewhat as a deterrent.

other hand there are conditions under which light should be used more liberally than is there indicated. In a dense fog none of these lighting installations can be depended upon to give sufficient protection. Under such conditions the guard must be increased or supplemented by alarm systems.

120. Flood lighting offers advantages for certain protective lighting installations. The units are easily installed and wired; they may be mounted for universal adjustment in order to provide quick emergency service for lighting any place within several hundred feet of their location; and they make possible the lighting of remote or inaccessible places.

It is necessary that flood lamps be installed and used with much circumspection in order to avoid glare. Preferably they should be turned in a common direction with the projection away from the guard and in the same direction or directions that the guard looks when patrolling the area lighted. They then serve not only to promote the guard's view, but also to conceal the guard from view by reason of the glare they produce in the eyes of others. Flood lamps used for lighting boundaries should not be installed in such a way that their beams meet; that is, turned so that they project toward each other. Such installation tends to render the lighting futile, the glare from each projector nullifying the lighting effect of the other.

If you blind anyone, blind the trespasser.

Deterioration.

121. All lighting equipments are liable to deterioration with age and are especially liable to become ineffective through accumulation of dirt. It has been found that in interiors where lighting fixtures are not maintained in a cleanly condition, losses of light result, ranging anywhere up to one-third of the total light produced. In protective outdoor lighting it should be anticipated that even greater losses will be incurred if attention is not paid to keeping the lighting fixtures in reasonably good and cleanly condition.

In manufacturing plants, where lighting equipment is subjected to smoke, acid fumes, etc., it is very important to exercise care in the selection and installation of the lighting fixtures. For example, most thin sheet metal will not withstand attacks of acid in steel mills; copper is one of the few materials which may be used for this purpose. White paint, unless it is made from good white lead, will turn yellow and peel off. In such plants the lighting installation should be of a sturdy, permanent character. Vapor-proof fixtures, as illustrated in the section on equipment, usually are desirable.

PROTECTIVE LIGHTING PRACTICE.

Practice described in this section is for protective lighting primarily. For industrial purposes more liberal use of light in the same areas will probably be found necessary.

Lighting of boundary fences.

201. A high fence around the boundary of a property is an important feature of protective methods. This fence should be preferably of barb wire or wire netting so constructed as to make it necessary for a trespasser to expend considerable time in surmounting or passing through it. If the fence is solid or opaque, it may with advantage be painted white, or whitewashed.

202. A boundary fence should be illuminated at night in order to ward off intruders and to simplify patrolling. Adequate illumination of the boundary fence not only makes for safety but also works for economy, in that it lessens the need for extensive patrol. There are two general practices of lighting such boundary fences, both of which have certain advantages, and either of which may be applied to advantage in most cases. They are described below.

Illumination of boundary fences by rows of reflector units.

203. The first method consists in locating a row of lamps of the second order[1] (par. 402) over the fence. These should be mounted 18 to 25 feet high. The spacing distance may vary from 50 to 150 feet, but preferably should not exceed four times the height of the units above the ground. When the larger units are used they should be mounted higher, but may be more widely spaced than when the smaller units are used. These units should be equipped preferably with shallow dome outdoor lighting reflectors (par. 404). Figure 3 illustrates an underground lighting installation for a wooden fence.

---

[1] Referring to the order of light output of the illuminant as classified in par. 402 of the section on lighting equipment.

204. For supplementary service there should be provided at each corner of the boundary and at other commanding points adjustable flood-lighting units of one of the several types listed in the section on lighting equipment. These should be available for the use of the guard, being capable of illuminating the line of the fence or any other point within a radius of several hundred feet. They should be supplied from independent circuits (par. 301).

205. It may be advantageous to locate the guard upon a raised platform which mounts the flood-lighting unit. In certain localities the best opportunity for fixed post guarding may be afforded in this way. Figures 4 and 5 are views of a lighted boundary fence from the ground and from a raised platform, respectively, indicating the advantage of the latter for purposes of observation.

Illumination of boundary fences by flood-lighting units.

206. A second method consists in locating flood-lighting units at the corners and at intervals along the boundary fence. Preferably these should be turned in the direction in which the patrol is carried out, so the guard may not be subjected to the glare which they are capable of producing. It usually is desirable to mount flood-lighting units at a height of 10 to 20 feet and with spacings of 150 to 200 feet. Figure 6 illustrates the effects secured in such service with 15° spread projectors; figure 7 with 25° spread projectors; and figure 8 with 45° spread projectors. In each case the projectors are 200 feet apart, mounted 10 feet above the ground. The narrow beam projectors provide relatively intense illumination of a narrow strip of ground, which is suitable for certain locations. Obviously with a given size projector unit the spacing intervals may be made greater if a narrow beam projector is used. It is better, however, to employ a fairly wide spread projector and adopt shorter spacing intervals, using more flood-lighting units. For best results, where wide spread projectors are employed, distances of 75 to 150 feet ought not to be exceeded. It is well to adjust the beam so that it falls just outside the fence, its edge corresponding with the fence. If the fence is not of the solid or opaque type, the guard may then patrol inside the fence in comparative obscurity.

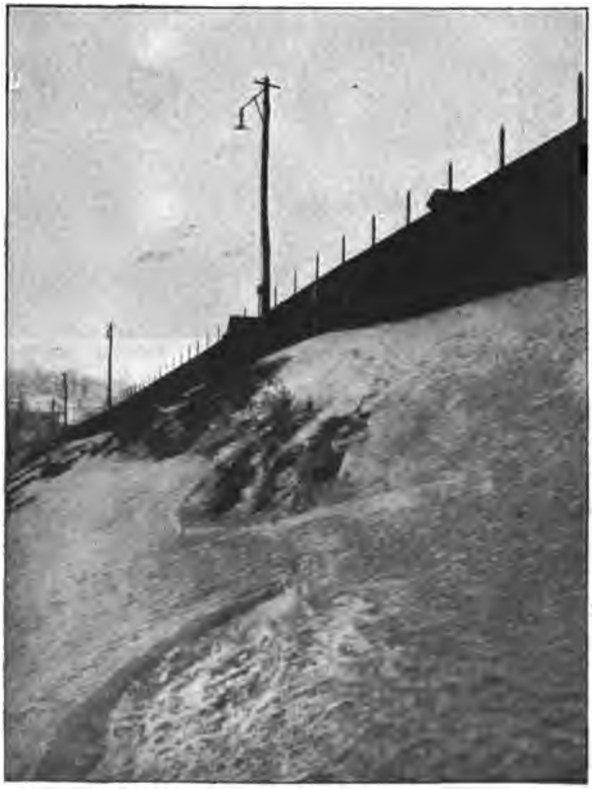

FIG. 3.—Protective lighting installation for boundary fence.

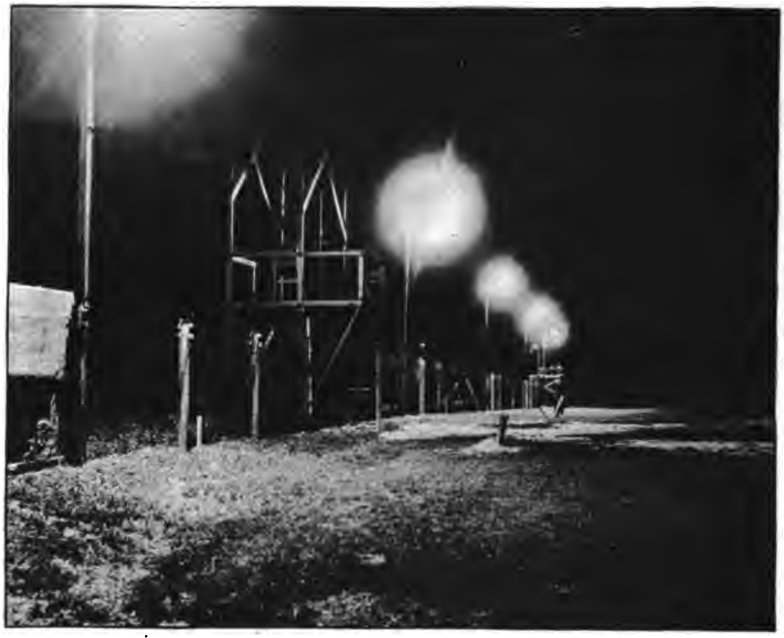

FIG. 4.

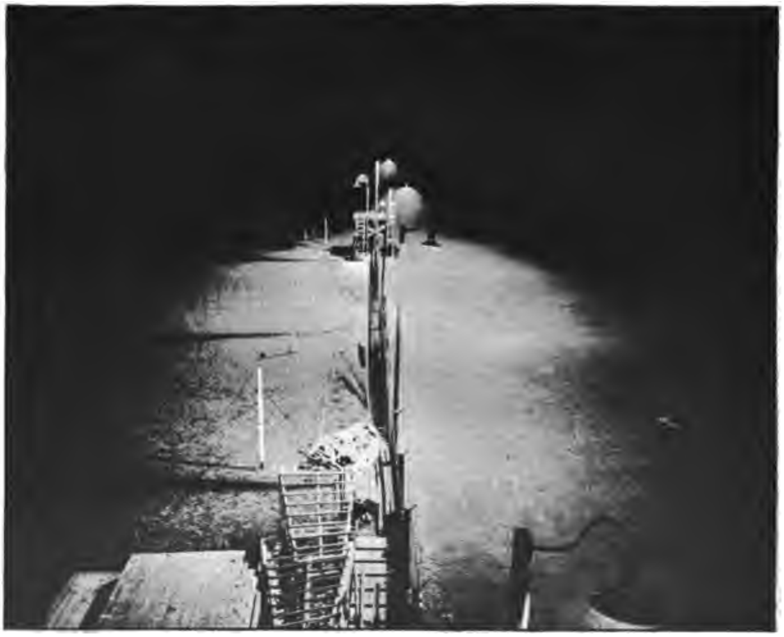

FIG. 5.

Protective lighting of boundary fence viewed from below and above.

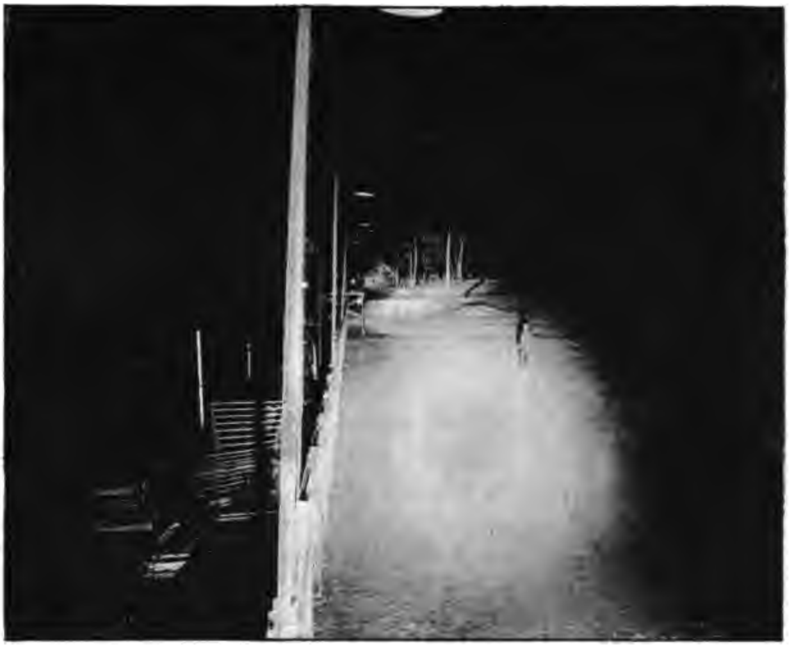

FIG. 6.—Protective lighting of boundary fence with flood-lighting unit having 15 degrees spread.

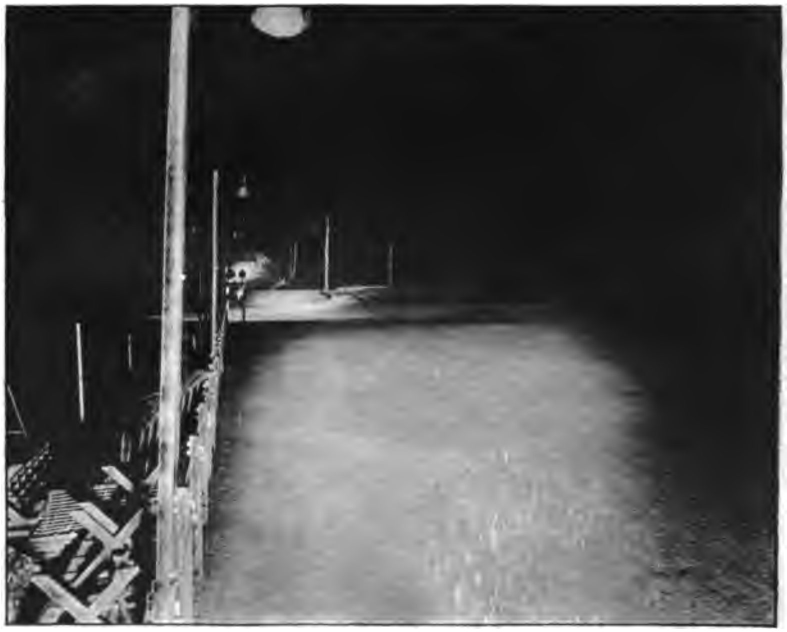

FIG. 7.—Protective lighting of boundary fence with flood-lighting unit having 25 degrees spread.

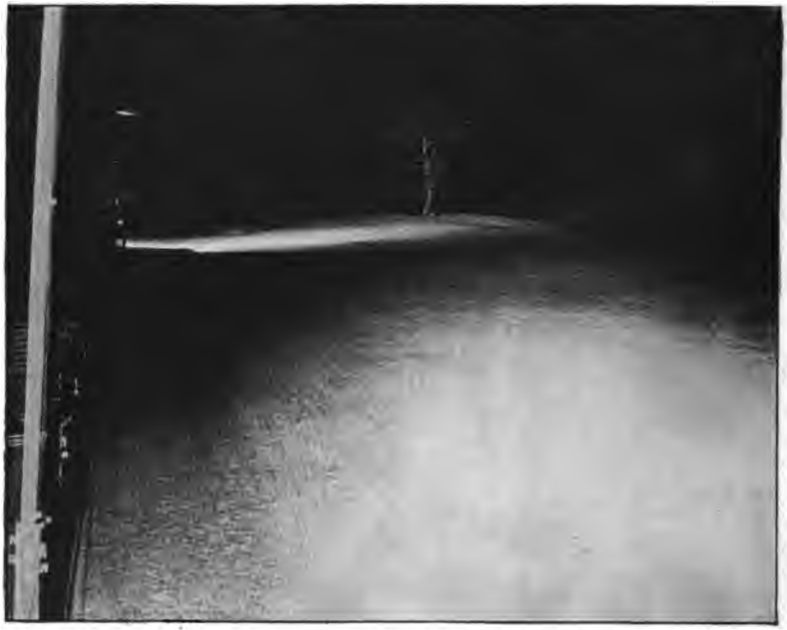

Fig. 8.—Protective lighting of boundary fence with flood-lighting unit having 45 degrees spread.

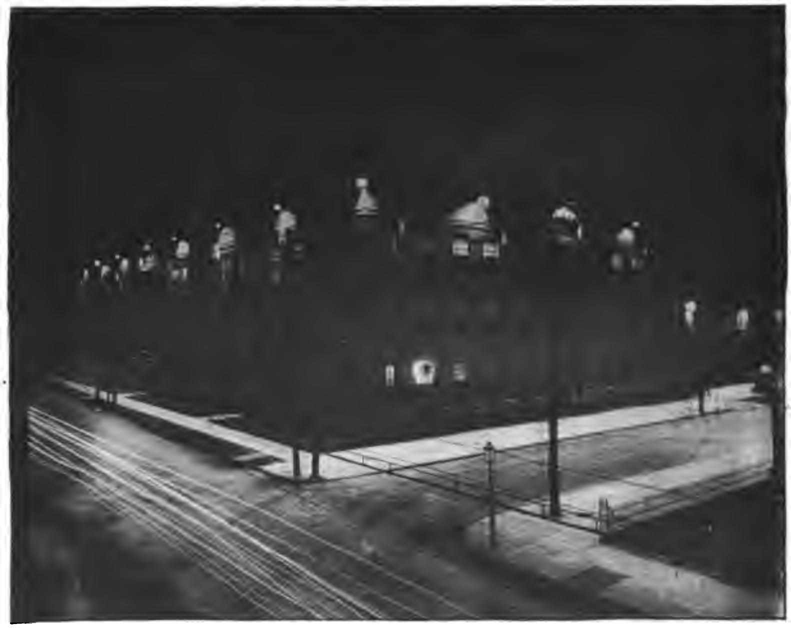

Fig. 9.—Protective lighting of building from reflector units on building face.

Lighting of approaches.

207. Long approaches to a protected property may be lighted by flood-lighting units directed into them. This serves well enough for guard purposes, but is a distressing form of lighting for those who approach the entrance on legitimate errands, unless the units are mounted quite high.

An alternative method is to employ some type of street lighting illuminant installed as in street lighting for a distance of at least 200 feet from the entrance.

LIGHTING OF BUILDING EXTERIORS.

Buildings located near boundaries.

208. If the building adjoins a street or railway, it requires special lighting. Reinforcement of the street lighting by more or larger similar units may serve in some cases. Generally, best results may be obtained by mounting lighting equipments upon the building (fig. 9). These are usually of the second order,[1] mounted at least 18 feet above the ground, and preferably higher, spaced at intervals of 50 to 100 feet. If the building is light—of high reflecting power—shallow dome reflectors may be employed, and the spacing intervals should not be more than three times the mounting height. A considerable part of the light thus falls upon the building, rendering it bright, and by reflection and diffusion adding to the direct light from the units effective upon the ground.

209. If the building is dark, angle reflector units may be used, and the spacing intervals should not exceed twice the mounting height.

210. If the guard operates principally from fixed post, the angle reflectors may be directed away from the corner of the building near which the guard is located.

211. All of these methods of lighting should be supplemented by independently supplied adjustable flood-lighting units located at corners of the building under control of the guard.

212. Diffusing globe units are sometimes used in lighting building exteriors. They are most useful when lamps are mounted low and near light buildings.

213. Whatever the form of lighting adopted, care should be taken to see that all nooks and corners are illuminated; otherwise, especially around dark buildings, there are likely to be dangerous shadows.

---

[1] Referring to the order of light output of the illuminant as classified in paragraph 402 of the section on lighting equipment.

Buildings located in open areas.

214. Such buildings may be guarded to some extent by a lighted boundary fence (par. 201). Where a building of dark finish does not front immediately upon a street which is lighted, it is customary to illuminate a zone of ground surrounding the building. This may provide a lighted strip, one edge of which is the building wall; or, the lighted strip may be separated from the building by a narrow unilluminated zone in which the guard may patrol. In either event a simple method of providing the illumination consists in mounting outdoor angle reflector units on the building. These should be spaced at distances not greater than twice the mounting height above the ground and where practicable should be at least 25 feet high. Lamps of the second order[1] are usually selected for this purpose. If angle reflector equipments are not available, a somewhat similar result can be had by tilting dome reflectors slightly out from the building in order to direct their light upon the ground surrounding the building, rather than upon the dark building surface.

It is desirable to provide one or more adjustable floodlighting units at opposite corners of the building, which under the control of the guard may be directed as required to supplement the fixed lighting, or may be brought into service in the event of interruption of the fixed lighting. Such flood lights should of course be supplied from separate service.

Street lighting systems for protection of buildings.

215. It is sometimes most convenient to install a street lighting system around the property, especially if there is a storage yard to be lighted. The usual practice in street lighting serves very well for this protective purpose. Lamps of the second order, mounted 18 to 25 feet above the ground on poles spaced 150 to 250 feet apart and equipped with refractors or diffusing globes serve this purpose. Here again it is desirable to provide adjustable flood lighting units at opposite corners of the building for use as auxiliaries.

216. Whatever the form of lighting, every care should be taken to safeguard the source of supply by rendering it inaccessible and by providing duplicate supply systems (par. 301).

---

[1] Referring to the order of light output of the illuminant as classified in paragraph 402 of the section on lighting equipment.

Additional lighting for gates, doorways, etc.

217. At all places of entrance or exit comparatively brilliant illumination is required over a small area. The location here of at least one lamp of the third order, mounted reasonably high, is desirable.

Protection of roofs.

218. Where a building is contiguous to other buildings, it is sometimes advisable to guard the roof. If the building to be protected is higher than the adjoining buildings, an excellent plan is to place a row of lamps just under the parapet of the guarded building. These may be angle reflector units to spread the light over the adjoining roof. The guard is located in the comparative darkness of the guarded roof. Where the roof of the property to be guarded is below that of the adjoining building, it is well, if possible, to locate the guard on the roof of the higher building, lighting the roof to be guarded by the method just described, or by flood lamps located on the higher building.

Protective lighting of yards, storage places, etc.

219. Where practicable, a well lighted boundary fence should serve as the first line of defense. Within such boundary lighting must be provided for protective purposes. This offers special difficulties because of the many obstructions to light which occasion undesirable shadows. Where the yard is bounded by buildings on one or more sides, angle reflector units, or flood lighting units, mounted high on the building, offer an excellent means of illuminating the yard. Illuminants of the first or second order, with a spacing not greater than twice the mounting height above the ground, serve satisfactorily. If the surface of the building is light, dome-shaped reflectors on brackets may be employed instead, these being spaced not more than three times their mounting height. To reduce shadows the illumination should be preferably from two sides for a small yard, from three or four sides for a larger yard, and from all four sides with supplementary illumination throughout the yard when very large areas have to be protected. Sometimes the guard may be located upon the roof of the adjoining building. The additional lighting in the yard itself, when a very large yard is to be protected, or all of the lighting for a yard, which is not bounded by buildings, may

be provided by street lighting units on poles spaced at intervals through the yard.

220. Where material is stored, it is difficult to avoid shadows. To that end the illuminants should be mounted relatively high and with relatively short spacing intervals. Where unobstructed areas are to be lighted, this is not so important. In general, illuminants of the second order may be mounted not less than 18 feet high and equipped with outdoor dome reflectors. They should be spaced at intervals of not more than four times the mounting height. In open yards similar units, equipped with refractors, may be given about double this spacing. Illuminants of the third order are occasionally used, mounted lower and spaced closer together. (Of course an open yard may be filled with obstructions at any time. Fairly high mounting of illuminants is therefore usually to be recommended.)

221. Careful consideration of locations for light sources is essential in yard lighting. In figure 10 excellent illumination of certain cars and driveways is provided, but the left foreground exhibits an unlighted space between the building and a line of cars which is a danger point.

222. For the illumination of yards, a certain minimum intensity is required for protective purposes. This is usually of an order requiring an expenditure of about 0.05 to 0.20 of a watt per square foot of illuminated surface, or about 0.004 to 0.02 cubic foot of gas per hour per square foot of illuminated surface. Often, however, illumination has to be provided to facilitate night work in such places. Intensities four or five times as great as those just indicated may then be required.

223. Whatever the system of illumination, provided for protective purposes in yards, it should be supplemented by one or more adjustable flood-lighting units at the disposal of the guard, served by separate supply, and available as a supplementary illuminating system for emergency purposes. The size and number of these flood-lighting units have to be determined in each case, with due consideration to the size of the area to be covered, and to the nature of materials and work performed in the area.

Limitations of flood lighting.

224. In general, in the fixed lighting of yards, flood-lighting units have a limited application, inasmuch as workmen must

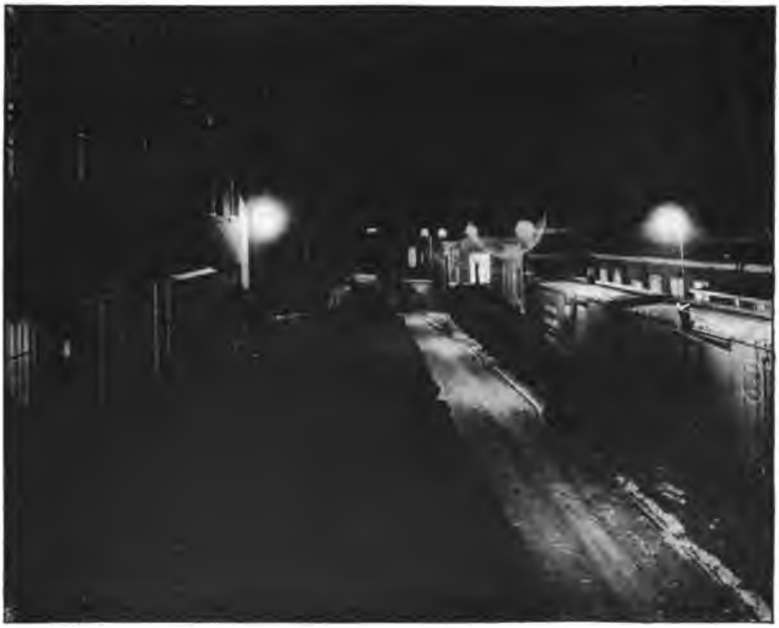

Fig. 10.—Protective lighting of freight yard. Note dangerous unlighted space in foreground.

16-1

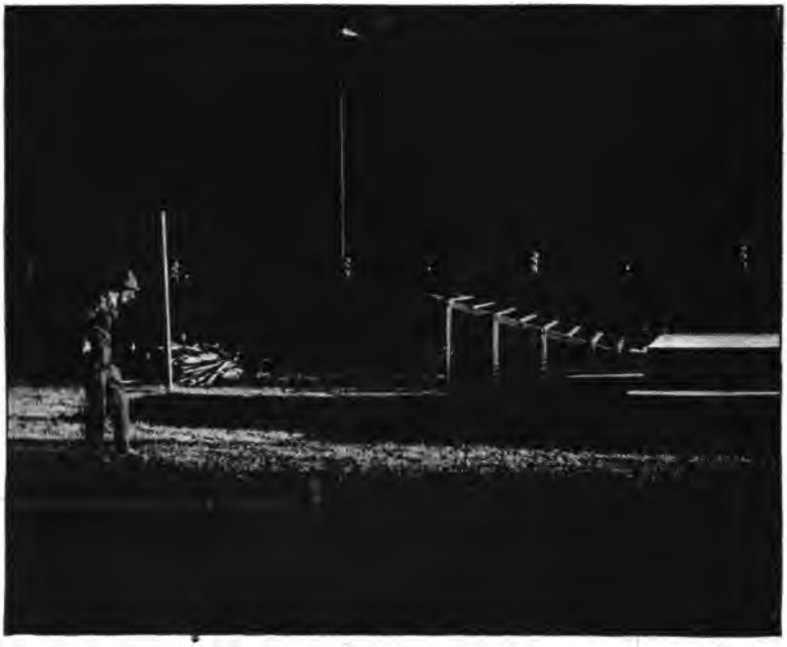

FIG. 11.—Protective lighting of yards by projectors is likely to result in dark shadows; the trespasser lurking within the shadow in this photograph can not be seen. (See fig. 12.)

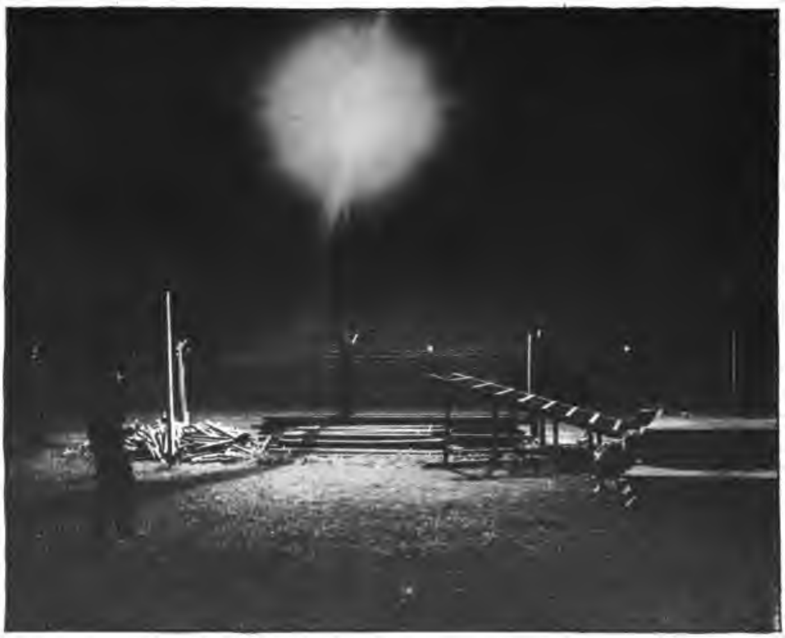

FIG. 12.—Protective lighting by units judiciously distributed leaves no dangerous shadows. (See fig. 11.)

move about in various directions, and it is difficult to protect them from the glare of such units. Likewise, the long narrow beams of light cause deep shadows when striking piles of material or other obstructions at a distance. This is well illustrated in figure 11 and figure 12. In figure 11 a shadow is caused by the pile of material in the foreground. If instead of the projectors placed at a distance, a distributed system of smaller lighting units were employed, as in figure 12, this shadow would be obviated, and the trespasser lurking within it would be revealed. Long, dark shadows not only provide a place of concealment, but they also menace the safety of workmen. The flood-lighting unit finds its principal application in yards for supplementary lighting and for illuminating little-used remote areas.

225. In all large areas which are to be lighted portable lighting units are useful auxiliaries for emergency purposes.

PROTECTIVE LIGHTING OF SHIPBUILDING PLANTS.

226. The continuous and rapid production of tonnage at the present time is of great military importance. This, together with certain peculiar features of shipbuilding plants, makes separate treatment of the protective lighting of such plants seem desirable. The great height of structures required for constructing and assembling parts of ships and the large extent of storage spaces make it desirable to use large illuminants of the first order, mounted high above all work places. Figures 13 and 14 show pole heads which have been designed for such units. The one shows angle reflector units below the cross-arm with a projector above, which may be fixed in order to illuminate any portion of a plant within range. The other shows dome reflectors below the cross-arm and two flood-lighting projectors of different size and type mounted above. Figure 15 shows a large improvised reflector covering two illuminants of the first order. The purpose of this device is to utilize the light with fair efficiency, while avoiding serious glare which sometimes is encountered when these powerful units in smaller reflectors are viewed against the dark sky. Where it is practicable, it is advantageous to station a watchman at a high observation point above the lighting units, connecting him by telephone with the several guardhouses. This affords him an excellent view of portions of the plant without any difficulty due to glare.

An illumination of not less than one-half foot-candle should be provided in all parts of a shipbuilding plant. The illumi-

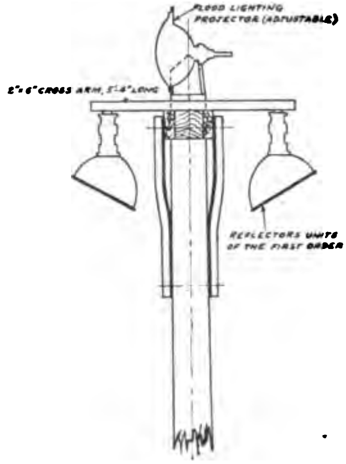
FLOOD LIGHTING PROJECTOR (ADJUSTABLE)
2"×6" CROSS ARM, 5'-4" LONG
REFLECTORS UNITS OF THE FIRST ORDER

FIG. 13.—Pole head mounting illuminants of the first order in angle reflectors with projector above cross-arm.

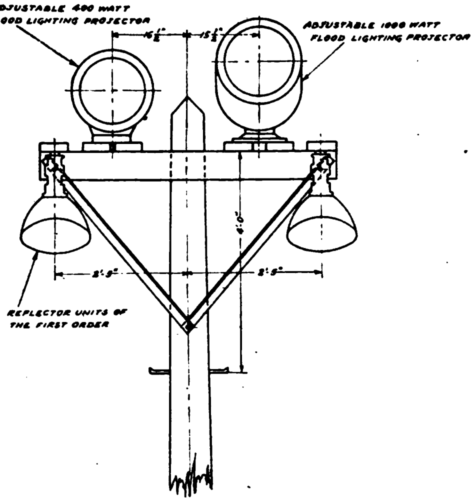
ADJUSTABLE 400 WATT FLOOD LIGHTING PROJECTOR
16½"
15½"
ADJUSTABLE 1000 WATT FLOOD LIGHTING PROJECTOR
4'-0"
2'-5"
2'-5"
REFLECTOR UNITS OF THE FIRST ORDER

FIG. 14.—Pole head mounting illuminants of the first order in dome reflectors with projectors above cross-arm.

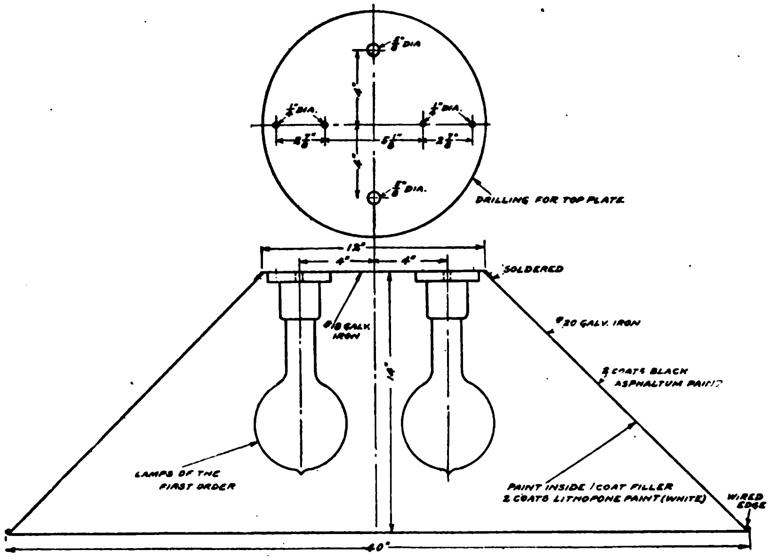

FIG. 15.—Large improvised reflector covering two illuminants of the first order. Large area of reflecting surface diminishes glare effect.

nation of the exteriors of ships under construction should be not less than 1 foot-candle. All areas in which work is done from time to time should be lighted continuously.

Protective lighting of water approaches.

227. A well-lighted zone beyond the ends of the slips or ways should be established. When the ways are properly lighted, no special lighting for this purpose is required. Unless such lighting is in operation continuously during the night time, special protective lighting, however, should be provided. Bulky materials for fitting out hulls are often stored on the water end of piers. In order to avoid obstruction of light by such materials, large illuminants of the first order should be used, mounted as high as practicable and so shaded on the water side as to avoid producing glare which will hinder pilots. In general such pier end lighting may be accomplished by dome outdoor reflectors of the second class mounted 30 to 50 feet high.

Protective lighting of open working or storage spaces.

228. Advantage may often be taken of high structures for mounting lighting units of the first order. Angle reflectors, dome reflectors and flood lights may all be necessary to accomplish the purpose of delivering light where it is needed without producing glare in the eyes of workmen. When such units are mounted upon buildings, they may be supplied from within the building. In any event the usual precautions should be taken to safeguard the supply and insure continuity of lighting (par. 301).

Protective lighting of other portions of the plant.

229. Passageways should be equipped with a dual lighting system consisting of lamps of the same type, supplied from different sources, or of lamps of two different types with different sources of supply.

The lighting for guard purposes of spaces between the decks of ships under construction may be accomplished by strings of small lamps, by small flood-lighting units, or by clusters of small lamps with flexible cable connection.

The lighting of permanent working platforms about steel ships may be handled in the same way.

It is important to light well the keel blocks of the ship. This may be accomplished by the installation of temporary circuits, supplying lamps of the third order.

There are three special points, the guarding of which should be carried out with greatest thoroughness. These are: The administration building in which drawings and plans are filed, the destruction of which would seriously hamper construction; the power house; and the ship itself as it nears completion, when injury would cause the greatest retardation of tonnage output. Precautionary methods of construction to secure immunity from interruption of lighting service (par. 301) should be adopted when providing for the illumination of such important portions of the plant.

Flood-lighting projectors.

230. While general illumination of the entire plant is to be recommended, supplementary lighting by projectors is of great value. These should be mounted as high as local conditions make practicable, and in such positions that they may be trained over as wide an area as possible. It is general testimony that moderate sized flood-lighting projectors are preferable for use in shipbuilding plants to those of highest power.

Emergency lighting units are especially useful adjuncts in shipbuilding plants. Where large ships are on the way, such lighting units can be employed both for working purposes and for protective purposes to good advantage.

Lighting of ship subsequent to launching.

231. A ship which has just been launched is exposed to attack, especially from the water side. To meet this hazard it is the practice in some plants to provide emergency lighting from portable units located on the upper deck of the ship or from flood lamps on the shore.

PROTECTIVE LIGHTING OF CONSTRUCTION WORK.

232. This in many respects is quite similar to the lighting of storage yards (par. 219). It is often difficult, however, to locate the light sources to advantage within the inclosure, yet protective lighting must be provided and often, in addition, lighting with which to prosecute the construction work. Projectors or angle reflector units mounted temporarily on hoist towers and parts of the structure offer a practicable means of lighting in some cases. Where a building consists of several floors, provision should be made in the early stages of the construction to run temporary circuits of armored cable and install a few lamps on each floor for protective purposes.

PROTECTIVE LIGHTING OF PIERS AND DOCKS.

233. Protective lighting of piers and docks is principally of two kinds: First, exterior lighting around boundaries of the property; and, second, lighting of the floor areas and interiors of piers. The plan of lighting underneath piers, among piles or other supporting members, does not appear to promise success. It seems preferable to install thorough protective lighting around the edges of the pier in order to provide a lighted zone through which trespassers will find it impossible to pass unobserved.

Lighting of sides and ends of piers.

234. In the lighting of piers and docks the value of white paint and whitewash is not to be overlooked. A given amount of light will prove a number of times as effective on a white or light colored pier as it is on a dark pier. The preferable plan for lighting the exteriors of covered piers is to install a row of outdoor lighting units around the outside of the pier structure. These may as a rule be mounted about 15 feet above the floor of the pier, and may be placed about 30 feet apart, care being taken not to allow them to project beyond the stringer beams, as in that case they might become entangled with shipping. Incandescent electric lamps of about 100 watts each will serve for this purpose. A closed or looped circuit, with the usual precautions to render the supply safe, is essential.

235. An alternative and generally less advantageous method of lighting pier exteriors is offered by the use of flood-lighting units. These should be mounted 10 to 20 feet above the pier floor, and so adjusted as to throw the beams along the pier walls and stringer beams. They should be directed away from the guard, and all along a given pier wall should be turned in the same direction. One 400-watt projector with small beam spread should be located every 250 feet. If projectors are used along the sides of the pier, a row of lamps across the pier end, as previously described, should be installed.

236. For important piers and docks the best method generally consists in installing rows of lamps, as described above, and supplementing them by one or more adjustable flood-lighting units, which, under the control of the guard, may be used to illuminate any spot around the pier exterior, or any part of the adjacent waters. A separate and well protected source of supply for these flood-lighting units should be provided.

237. When the pier is not covered, either an adaptation of the methods just described for the exterior lighting of covered piers must be provided, or the lighting of the pier floor area discussed in the following paragraphs must be so adapted as to provide a protective zone of illumination around the stringer beams or other boundaries of the pier.

Lighting of pier and dock floor areas.

238. Where there is a building structure at the shore end of the pier, it is often possible to mount angle-reflecting units and flood-lighting units high on the building for the illumination of the open pier or dock. By mounting them high they may be turned toward the water without impeding navigation. If the pier is not very long, the erection of poles at the corners of the outer end of the pier may provide supports sufficient for the mounting of the necessary additional lighting units of either the shallow dome or refractor type. On large piers, in spite of the obvious objections, it becomes necessary to erect a high pole, or high poles, at intervals along the pier for lighting purposes. The same practices described in connection with yard lighting (par. 219) here obtain.

Approaches to piers.

239. The protective lighting of structures at the land approaches to piers is substantially similar to that of the protective lighting of buildings (par. 208). The lighting of the water approaches is an entirely different matter. The lighting of pier exteriors will provide for a zone of illumination across all water approaches. One or more of the adjustable flood-lighting units provided as auxiliary to the fixed exterior lighting system should be so located that all approaches by water will be within flood-lighting range. This permits ready examination of any suspected object on the water, and a sweep of the flood-lighting beam across the water approaches from time to time will provide a measure of protection. If it is considered important to light the water approaches, flood-lighting units of, say, the 400-watt size should be located on the pier 75 to 150 feet apart. For guard purposes these may be mounted quite low, but in such positions they interfere with navigation. A compromise between these two considerations will probably result in the mounting of flood-lighting units at a height of 25 feet above the surface of the water and tilting them downward.

PROTECTIVE LIGHTING OF BRIDGES.

Lighting of approaches.

240. Thorough protection of a public bridge necessitates an area of strong illumination at each end of the bridge, in order to facilitate examination by the guard of persons and materials approaching the bridge. This may be provided by the installation of a few street-lighting units at each approach to the bridge, which will illuminate the approach for a distance of at least 200 feet. Assuming that there is a guardhouse, it is desirable to have a lighting unit of, say, the second order mounted over the door of the guardhouse to facilitate close examination by the guard.

Lighting of travel ways.

241. Along all travel ways of the bridge a usual street-lighting system should be installed. Illuminants of the second order, placed not more than 100 feet apart and mounted 18 to 25 feet above the roadway, will serve. These may be equipped with bowl reflectors or with opal globes, as desired. If the bridge is large, with roadways and sidewalks, smaller illuminants may be installed over the latter.

Lighting of foundations.

242. The problem of lighting piers and abutments of bridges is quite similar to that of providing protective illumination for buildings and pier exteriors (pars. 208 and 234). Choice is offered of the plan of illuminating the bridge foundations or of surrounding each of them with a zone of light.

Adjustable flood-lighting units under the control of the guard should be available near the bridge foundations for the illumination of any portion of the bridge, the illumination of the opposite bridge pier, and the illumination of the water or ravine and surrounding area.

Lighting of private unlighted bridges.

243. In the case of railroad or other unlighted bridges, where the bridge is not open to the public, flood-lighting projectors mounted near the ends of the bridge and trained on the bridge may be used to advantage. If adjustable, they may be so located as to bring practically every portion of the bridge

structure within their ranges. The size of lamps and beam spread of these flood-lighting units should be selected with reference to each installation (par. 408). In lighting railroad bridges, care must be taken not to interfere with the view of the railway signals.

244. In the lighting of bridges it is usually considered desirable not to emphasize by special illumination vital points in the structure, such as keystones, anchor piers, etc. These should be well lighted, as are the other portions of the bridge, but attention should not be directed to them by special lighting. The guards should watch these points with special care instead of relying upon extra illumination to reveal a menace.

PROTECTIVE LIGHTING FOR DAMS AND LOCKS.

245. At dams and along locks, prismatic refractor or dome enameled steel reflector units with lamps of 200 or 300 watts will provide adequate illumination if mounted 18 to 20 feet high and placed at intervals of from 75 to 150 feet; the refractor equipments being of course more suitable for use with the wider spacings. Such equipment should be supplemented by narrow beam flood lighting units to be used for sweeping the approaches, or illuminating them continuously, as may be desired. For a wide stream an incandescent searchlight should be installed on each bank to light the stretch of water above the dam, and thus prevent attack by water. Log booms or nets where practicable of use offer additional protection, and should be within the zone of such illumination. Where electric service is not readily available, the use of self-contained portable flares (par. 411) is sometimes advantageous.

PROTECTIVE LIGHTING OF INTERIORS.

Industrial lighting does not always suffice.

246. Adequate interior illumination for industrial purposes usually fulfills all requirements of protective lighting, except those of safety installation designed to assure continuity of service. But lighting for industrial purposes[1] is often inadequate. It is therefore desirable in protective lighting to ex-

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[1] For authoritative discussion of industrial lighting see "Code of Lighting Factories, Mills, and other Work Places," Transactions Illuminating Engineering Society, November, 1915; and Revised Rules, same publication, April, 1918.

amine the interior illumination with respect to its immunity from service interruptions, accidental or malicious, and to its effectiveness in preventing, among other things, (1) malicious tampering with machines and product sabotage in general, and (2) planting of explosive or incendiary bombs in working space, passageways, stairways, etc. To be effective in these matters the interior lighting system should enable the man in charge of a given portion of the building to have a clear view of the men, machines, materials, etc., in any portion of the building under his jurisdiction. This will at once suggest that, irrespective of local lighting, there must be a general overhead-lighting system, the illuminants of which shall be equipped with reflectors or diffusing globes. A good general system of illumination should be supplemented by good housekeeping. Rubbish, dirt and scrap invariably seek dark areas, such as space under workbenches, and in remote corners of a building. These offer opportunities for placing destructive instruments resulting in explosion or fires. If a building is kept free from rubbish, this danger is lessened. Good illumination makes the possibility of placing such destructive instruments rather remote, even where rubbish is allowed to accumulate, but good housekeeping and good lighting together offer effectual protection.

Unfrequented places must be lighted.

247. Stairways, passageways, overhead bridges, elevated gangways, and other unfrequented places are especially vulnerable, for the reason that generally they are inadequately lighted, if lighted at all. The excuse that these are unimportant parts of the plant is of no value in case of accident or fire. Adequate illumination of these little-used portions of a building is an essential feature of interior protective lighting.

Stairways should have one or more illuminants of the third order equipped with a dome reflector or a diffusing globe located over each landing, and as far as possible out of the direct line of vision. Similar lighting units should be used in the other unfrequented portions of the building, spaced with 10 or 15 foot centers, as may be indicated by a practicable mounting height and type of reflector or globe employed.

Interior storage spaces should be adequately lighted at all times, with special lighting provided for points of egress and ingress. This is especially important in chemical and explosive plants, where opportunities for the willful mixing of chemicals offer occasion for causing damage to the plant.

Natural light sometimes insufficient.

248. Wherever the natural lighting conditions are found to be inadequate, artificial lighting should be provided in the daytime. Most plants, except those of very recent construction, have this problem to deal with, and even the latter meet the problem in basements of buildings. The sections having inadequate natural light are likely to be used for minor operations or for storage. These spaces lend themselves especially to the purposes of sabotage.

Outdoor auxiliary lighting systems for interiors.

249. Elsewhere auxiliary lighting systems have been discussed (par. 301). A type of auxiliary lighting for protective purposes, which for certain classes of installations has much to commend it, is as follows, being illustrated in figures 16 and 17.

Angle type reflector units, with weatherproof porcelain sockets supported from an iron weatherproof box, are installed on the outside of the tops of windows, directing light in through the windows. Lamps of the second order are used, being located not more than 25 feet apart. These outdoor lamps are controlled both from the guardhouse and from a convenient point within the building, so that when required, they may be put into service by either the outside guard or by the watchman within the building (for safety installation of such an auxiliary lighting system, see par. 303).

The lighting serves a number of constructive purposes.

250. Good housekeeping, sanitation, and good lighting are so intimately associated in accident prevention, welfare, and morale of workers, that even without the protective requirement there should be ample incentive to provide adequate illumination. The need for protection to which the war has given rise adds a new incentive, which makes it inexcusable for those responsible for important property to overlook its importance. Liability and compensation insurance companies are actively engaged in promoting improvement along these lines. Experts upon the staffs of such companies are at the disposal of policyholders for advice and service in this connection.

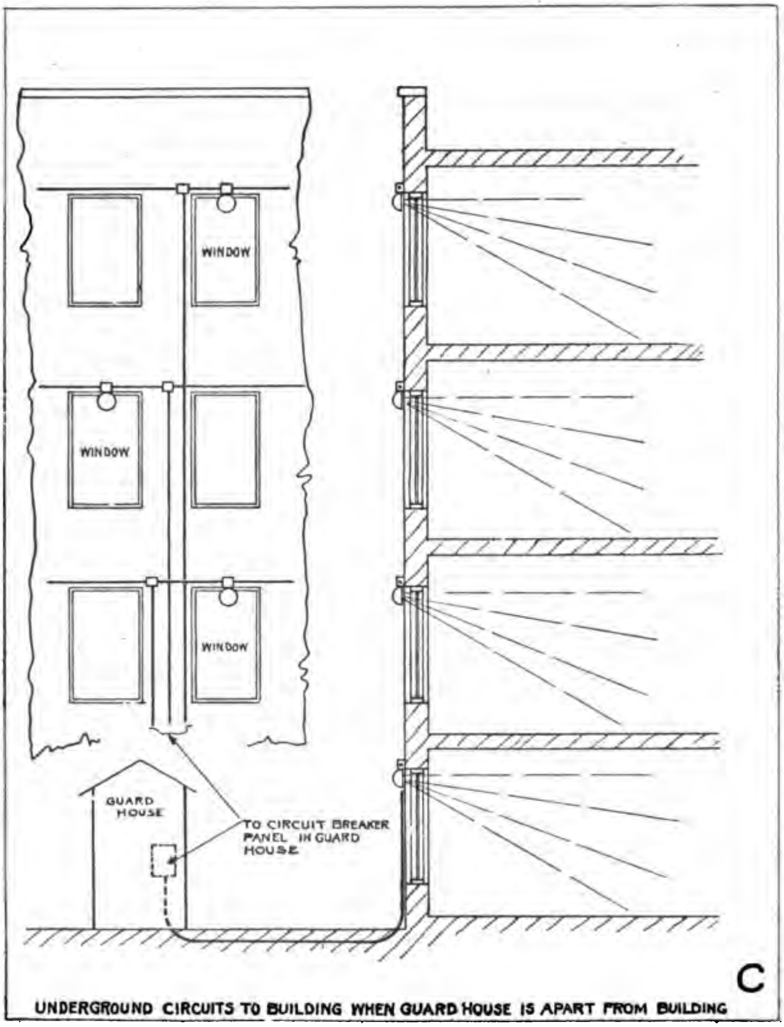
WINDOW
WINDOW
WINDOW
GUARD HOUSE
TO CIRCUIT BREAKER PANEL IN GUARD HOUSE
C
UNDERGROUND CIRCUITS TO BUILDING WHEN GUARD HOUSE IS APART FROM BUILDING

Fig. 16.—Protective interior lighting from exterior lighting units.

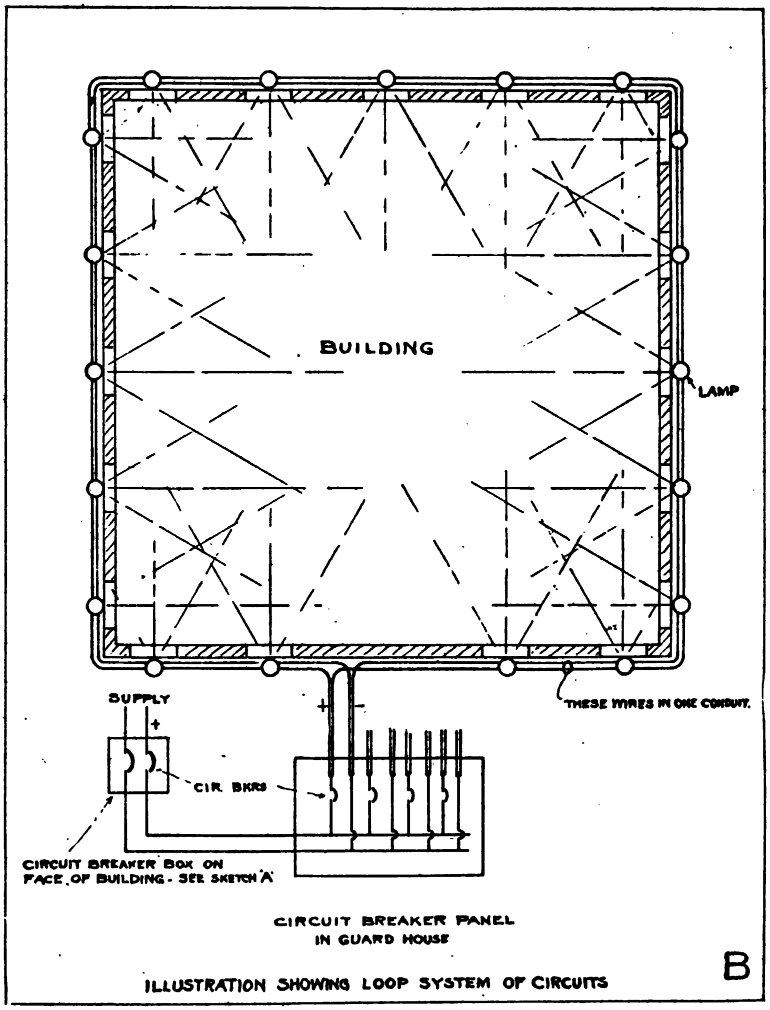
BUILDING
LAMP
THESE WIRES IN ONE CONDUIT.
SUPPLY
+
+
-
CIR. BKRS
CIRCUIT BREAKER BOX ON
FACE OF BUILDING - SEE SKETCH 'A'
CIRCUIT BREAKER PANEL
IN GUARD HOUSE
ILLUSTRATION SHOWING LOOP SYSTEM OF CIRCUITS
B

FIG. 17.—Plan for protective interior lighting from exterior lighting units.

Portable self-contained light sources.

251. In buildings where continuous operation of portions of the lighting system is not practiced during the night, circuits may be arranged so that patrolling night watchmen may turn on the lights at one point and extinguish them at another point of their rounds. If provision is not made for this, some form of portable lighting unit should be at the disposal of the watchmen. The kerosene-oil lantern is barred in some industries, and is under the ban of the fire underwriters. Electric dry-battery hand lamps are to be recommended as a substitute for this purpose (par. 411).

SAFETY METHODS OF CONSTRUCTION AND INSTALLATION IN PROTECTIVE LIGHTING.

Construction for underground electrical distribution.

301. For protective lighting, underground service offers manifest advantages. Low-tension multiple circuits can usually be located underground in yards or just outside buildings, and should be so located preferably that the surface line of the run can be under constant observation of the guard. Lead-covered insulated cables should be pulled through iron conduit which is buried below ground from 20 to 24 inches. The ends of all pipe should be carefully reamed and pipe coupling joints red leaded, being made tight, and as nearly as possible waterproof. Handholes without surface evidence should be located approximately 100 to 125 feet apart on straight runs. These may be of concrete not less than 6 inches in thickness with a cover of similar concrete or of iron not less than 3/8 inch thick. The bottom of such handholes may be about 2 feet 6 inches below grade. The inside depth of the box should be about 1 foot, in order to retain properly the splices necessary in such small wire circuit work. The iron pipe on entering the handhole box should end flush with the inside face of the wall. The end of the pipe should be thoroughly reamed and the cable should be racked carefully round the walls of the box, avoiding sharp bends or cracks in the lead sheathing. It is well to locate the T connection from the handhole box to the lighting circuit a few feet to one side of the vertical pipe carrying the lighting circuits. If conditions are such as to require a larger box or manhole with exposed cover at grade, this box should be of the standard type, where two covers are used, the inner cover being bolted down and locked

in position. Such manhole cover should be located where it is constantly under observation of the guard. Such underground circuits should not be connected or installed in close proximity to other underground electric systems of any kind.

Electrical construction for exterior protective lighting.

302. The protective lighting system should be supplied from more than one source. The service connections should be made near, and preferably directly above, the guardhouse, so that they may be constantly under observation and easily accessible. The service should be inclosed in a weatherproof iron box and controlled by a circuit breaker rather than by fuses, on account of the greater facility which the circuit breaker offers for prompt restoration of service after interruption. The circuit breaker should be controlled and operated from the guardhouse, as for example, by means of a rod to a ring attached to the circuit breaker. An arrangement of this character is indicated in figure 18 for overhead and underground service. From the service a main should run from the face of the building in iron conduit to a panel in the guardhouse, from which point the various multiple lighting circuits will be distributed. If the guardhouse is detached from the building, this main feed and the circuits distributed from it should be run underground between the building and the guardhouse. Each of these circuits should be protected by a circuit breaker. These lighting circuits should be in standard iron conduit, wired in a loop, both ends of which are connected to the panel in order to make interruption of the lighting service more difficult. When the conduits are mounted upon the building exterior they should be placed 15 to 20 feet above the ground, and either carefully concealed from view or else entirely exposed to view, so that in the latter case they may be under the observation of the guard.

303. If emergency outdoor lighting is provided for the protection of interiors, the lamps which light a given floor through the windows should be wired on a single circuit from the panel in the guardhouse (fig. 17).

304. In general, multiple circuits are preferable to series circuits for protective lighting. If series circuits are used, it is well to install them in complete duplication, providing separate transformers and circuits with lamps on alternate poles fed from

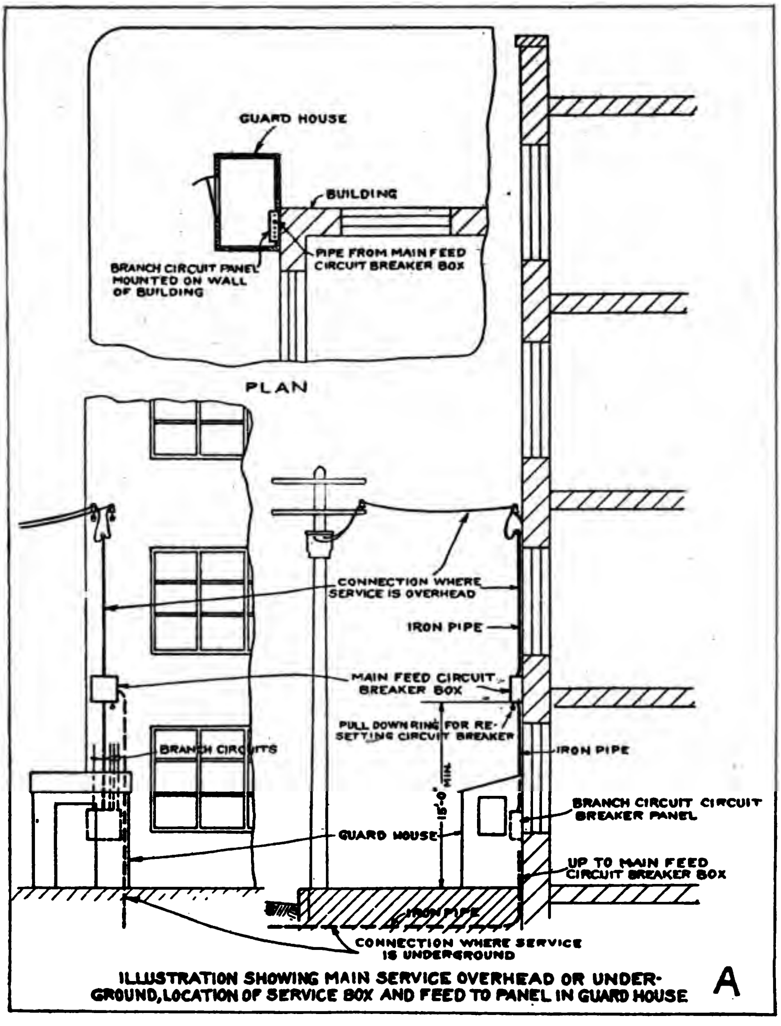
GUARD HOUSE
BUILDING
PIPE FROM MAIN FEED CIRCUIT BREAKER BOX
BRANCH CIRCUIT PANEL MOUNTED ON WALL OF BUILDING
PLAN
CONNECTION WHERE SERVICE IS OVERHEAD
IRON PIPE
MAIN FEED CIRCUIT BREAKER BOX
PULL DOWN RING FOR RE-SETTING CIRCUIT BREAKER
BRANCH CIRCUITS
IRON PIPE
15'-0" MIN.
BRANCH CIRCUIT CIRCUIT BREAKER PANEL
GUARD HOUSE
UP TO MAIN FEED CIRCUIT BREAKER BOX
IRON PIPE
CONNECTION WHERE SERVICE IS UNDERGROUND
ILLUSTRATION SHOWING MAIN SERVICE OVERHEAD OR UNDERGROUND, LOCATION OF SERVICE BOX AND FEED TO PANEL IN GUARD HOUSE
A

FIG. 18.—Safety construction of electric circuits.

the respective circuits. The transformer stations in such service should be well lighted and should be so located as to be under the constant observation of the guard.

Electrical construction for interior protective lighting.

305. The service entering a building, including switchboard, bus bars, meters, etc., should be inclosed in an iron grating the door of which should be kept clear from obstructions and accessible at all times to the person in charge. The service switch should be controlled by a circuit breaker in addition to or instead of fuses. Mains and feeds run into panels should be installed in iron conduit in a loop system. Panels should be inclosed in a steel box and should be so located as to be under constant surveillance. Circuits from panels should be run in iron conduit, concealed where practicable, but otherwise located conspicuously.

306. It is an excellent plan to locate in every floor, room, or section, a few lamps connected with a panel board located elsewhere. All circuits of course should be run in the loop system, and where practicable, the loop ends should be connected to service on different floors or in different rooms, thus making the wiring system difficult of comprehension except to one thoroughly familiar with the installation. Motors and lamps should never be on the same circuit.

Fixtures.

307. In chemical works and other places where gases are present, vapor-proof fixtures should be used, and wire guards. Where extreme precautions are necessary, automatic cut-offs can be devised which will operate to open the circuit when the wire guard is removed before detaching the lamp.

Electrical circuits for auxiliary lighting systems.

308. If the auxiliary lamps are of the same type as those relied upon for the principal lighting, they may be interspersed among the latter in proportions up to 50 per cent of the total lamps. They should be supplied from separate panels remote from those supplying the principal system.

309. Where other types of lamps are used as auxiliaries, the same practice is advisable. In either event a precaution which

may have valuable results consists in bringing into the building underground circuits for the principal lighting supply and overhead circuits for the auxiliary lighting.

Safety construction in gas-lighting systems.

310. *Outdoor piping.*—Underground gas piping should be laid sufficiently deep to protect it against frost. In latitudes above 40 degrees, it should be not less than 2 feet 6 inches deep.

Underground piping in and around the plant should be installed as an inclosed system, with few or no dead ends. This system should be connected, if possible, with the mains of the gas company at several different points, so that if the supply through one should fail, others will hold.

The sizes of piping should be determined by a local gas man familiar with the conditions. No underground pipe should be smaller than 1¼ inches.

Any system of underground piping should be laid so as to drain to one or more points, from which the collected drippings may be pumped as required.

Posts on which the lamps are mounted should be preferably of steel tubing. This material will serve to protect, against malicious attack, the riser pipe inside the post better than will cast iron or other material.

No riser pipe in a post should be smaller than ¾ inch.

No piping exposed to outdoor temperatures, as in bracket lamps hung from buildings, etc., should be smaller than ¾ inch.

Indoor piping.—The interior system of piping should be an inclosed system, with as few dead ends as possible. This inclosed system should, if possible, be supplied at several points through different service and meters. If possible, these different services should come into the plant on different streets, so that the meters will be widely separated.

As a rule, stopcocks on interior piping for protective lighting purposes are to be avoided, except at the inlets of meters.

LIGHTING EQUIPMENTS.

401. Equipment for protective lighting indoors does not differ materially from that used for industrial lighting, which in most cases will have been provided. New installations, however, will be required largely for exterior protective lighting. On this account the lighting equipment listed in this section consists principally of the types employed outdoors.

The equipments listed are those which may be used in installations of the kinds described in previous pages for special purposes. Equipments typical of their kinds are illustrated without regard to the manufacturer represented. For information as to prices, deliveries, and further details, application should be made to manufacturers, jobbers, or dealers.

402. *Light sources dependent upon a central supply—*

Classified roughly as to the order of light output—

Order.

I. 750 and 1,000 watt multiple Mazda C lamps. 6.6 ampere series magnetite arc lamps. Multiple and series flame arc lamps.

II. 200, 300, 400, and 500 watt multiple Mazda C lamps.
250, 400, 600, and 1,000 candlepower series Mazda C lamps.
4 and 5 ampere series magnetite arc lamps.
3 and 5 mantle inverted gas lamps.

III. 60, 75, 100, and 150 watt multiple Mazda lamps.
Single mantle upright, and two-mantle inverted gas lamps.

REFLECTORS AND GLOBES FOR USE WITH ELECTRIC AND GAS LAMPS.

CLASSIFIED ROUGHLY WITH RESPECT TO DEGREE OF CONTROL EXERCISED OVER THE LIGHT.

403. Diffusing globes or other equipments distributing light in nearly all directions:

Available for all electric and gas lamps. For most protective lighting in which diffusing globes are used, units similar to those illustrated, which direct a large proportion of light below the horizontal, should be selected. In general, diffusing globes are suitable for use in protective lighting only where they will be viewed against a well-lighted background, and where the illuminants are mounted relatively low. They are, of course, liable to breakage. Aesthetic considerations sometimes dictate the use of these equipments for protective lighting where the units are visible to the public, as along streets. Weatherproof equipment should be used.

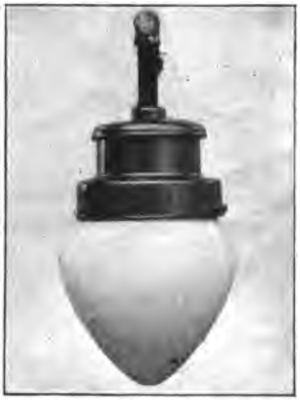

FIG. 19.—Fixture for electric lamp with diffusing globe.

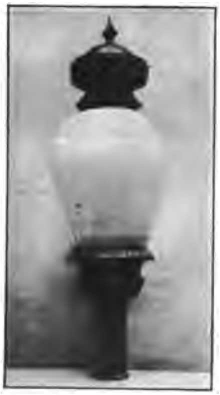

FIG. 20.—2-mantle inverted gas lamp with diffusing globe.

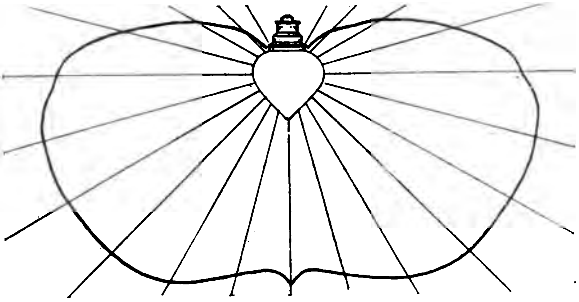

FIG. 21.—Distribution of candlepower in a vertical plane typical of this class of units.

404. Dome-shaped opaque reflector units:

Available for all incandescent lamps and for gas lamps of the second order; 75 to 80 per cent of light from the source is delivered below the horizontal.

Deeper reflectors than those of the dome type are also available for locations where low mounting height makes this added protection desirable. Porcelain enameled steel reflectors are best adapted to withstand outdoor conditions and retain their efficiency. Reflectors with paint enamel surface, tin shades, etc., while cheaper in first cost, will not be found permanently efficient. Weatherproof equipment should always be specified.

FIG. 22.—Heavy duty metal reflector for electric lamp.

FIG. 23.—5-mantle inverted gas lamp.

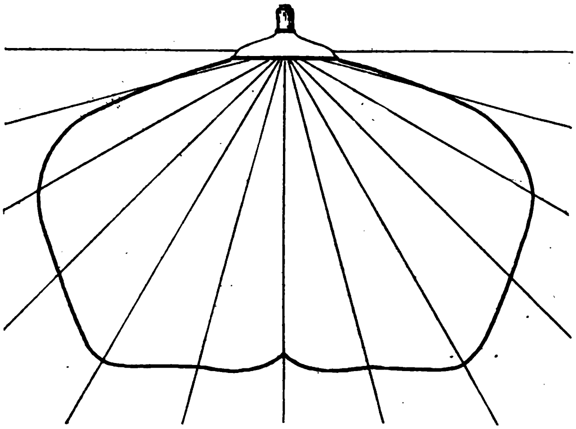

FIG. 24.—Distribution of candlepower in a vertical plane typical of this class of units.

405. Angle opaque reflector units—

Available for all electric incandescent lamps and for gas lamps of the second order. About 60 per cent of light from source is delivered below the horizontal.

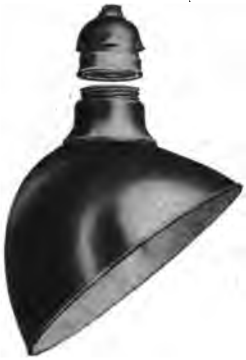

FIG. 25.

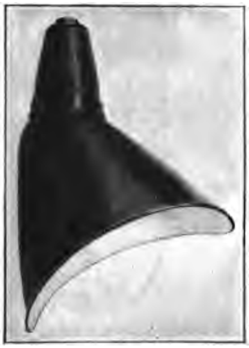

FIG. 26.

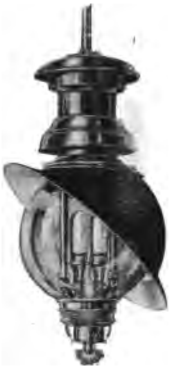

FIG. 27.

FIGS. 25 and 26.—Angle reflectors for electric lamps.
FIG. 27.—Gas mantle lamp equipped with angle reflector.

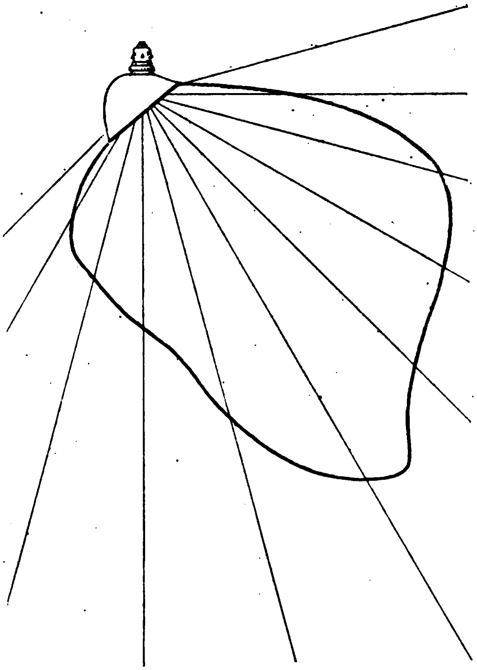

FIG. 28—Candlepower in vertical plane of maximum distribution typical of this class of units.

406. Vapor-proof unit—

Available for electric incandescent lamps. May be equipped with reflectors.

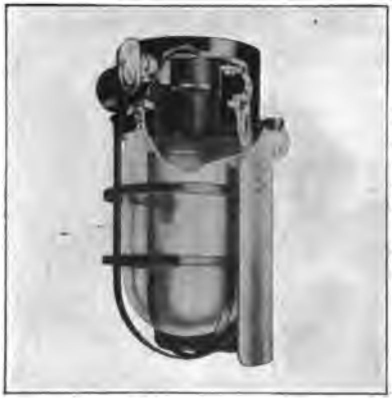

FIG. 29.—Vapor-proof unit for incandescent electric lamp.

407. Prismatic refractor units—

Available for all electric incandescent lamps, for magnetite arc lamps and for gas lamps of the third order. Sixty to 70 per cent of the light from the source is delivered below the horizontal.

For protective lighting, prismatic refractor units should be ordered to deliver maximum candlepower not less than 15° below the horizontal.

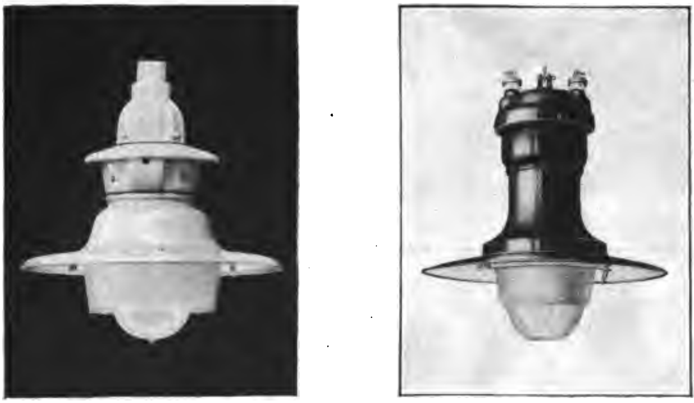

FIG. 30. FIG. 31.

FIGS 30 and 31.—Band refractor units—Lamp on left equipped for bracket mounting.

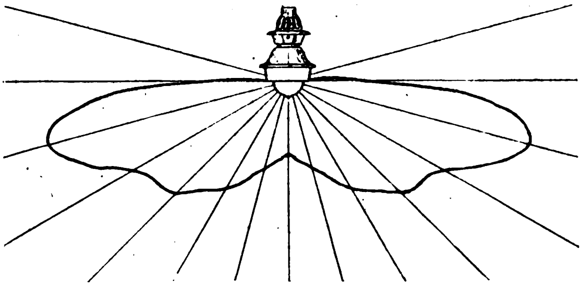

FIG. 32.—Distribution of candlepower in vertical plane typical of this class of units.

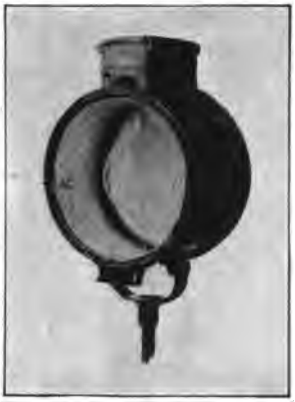

FIG. 33.

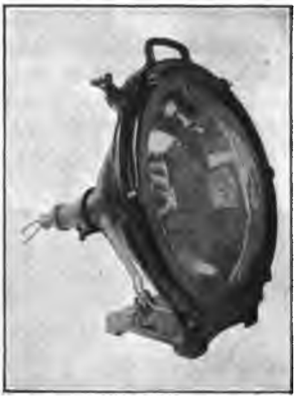

FIG. 34.

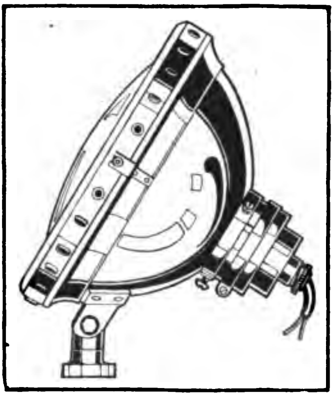

Fig. 35.

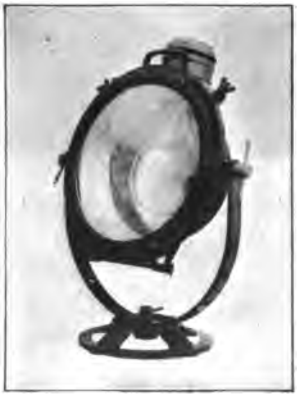

FIG. 36.

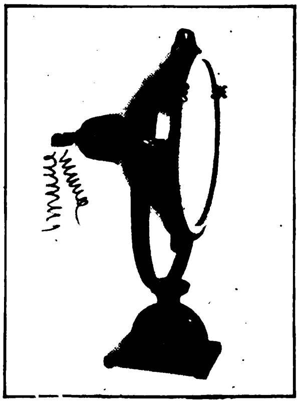

FIG. 37.

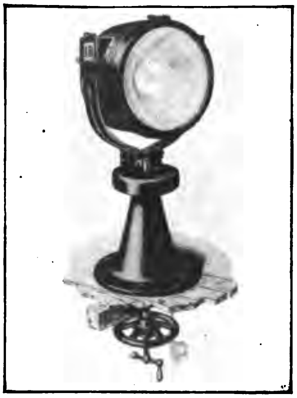

FIG. 38.

FIGS. 33–38.—Various types of flood-lighting projectors.

408. Flood-lighting projectors—

(*a*) Beam spread 8° to 15°—

Available for Mazda C flood-lighting lamps of 200 and 400 watts.

Percentage of light from the source delivered in beam, 20 to 40.

(*b*) Beam spread 12° to 24°—

Available for Mazda C flood-lighting lamps of 200 and 400 watts.

Percentage of light from source delivered in beam, 30 to 50.

(*c*) Beam spread 20° to 50°—

Available for regular multiple Mazda C lamps of 300 to 1,000 watts.

Percentage of light from source delivered in beam, 20 to 40.

(*d*) Beam spread 40° to 50°—

Available for Mazda C flood-lighting lamps of 400 watts.

Percentage of light from source delivered in beam, 40.

Flood-lighting projectors are usually made with reflectors of nickel plate, polished aluminum, or mirrored glass. The glass reflectors direct from 25 to 35 per cent more light into the beam than do the metal units. Another important characteristic in determining the efficiency and varying with the product of various manufacturers is the depth of the reflector; that is, the percentage of the light from the lamps intercepted and redirected into the beam.

409. Incandescent searchlight—

Diameter, 16 inches to 30 inches.

Available for Mazda C lamps of 550 to 1,000 watts with highly concentrated filaments.

Beam candlepower, 1,000,000 to 5,000,000.

Range—distances at which a man may be seen—1,000 to 2,500 feet.

More powerful arc searchlights are used particularly by military and naval forces. They are seldom required for protective lighting and may become a source of annoyance at great distances from a plant.

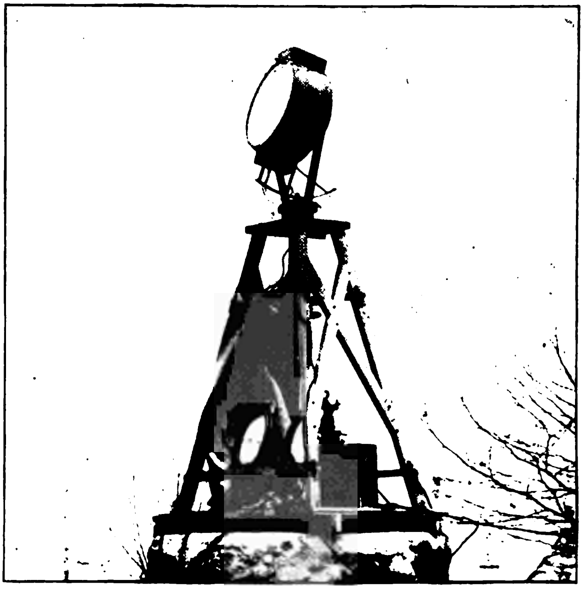

FIG. 39.—Incandescent searchlight.

410. Self-contained units—

Self-contained units capable of operation for periods of from several hours to several nights without renewal of energy supply are available for both permanent lighting of locations remote from a central energy supply and for emergency service. Among those available for such permanent lighting are the following:

Gasoline incandescent-mantle street-lighting unit with gravity feed. Third order.

Pressure-feed gasoline-mantle units of the second and third orders.

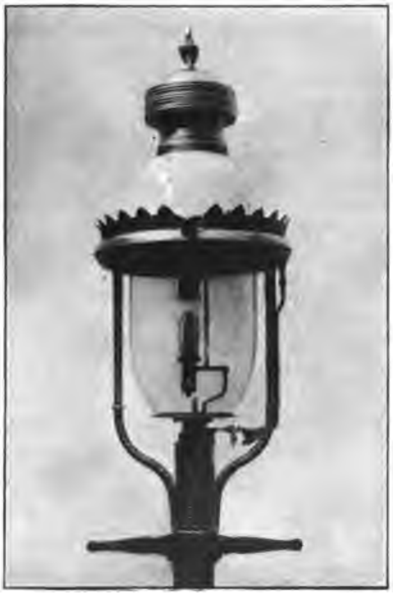

FIG. 40.

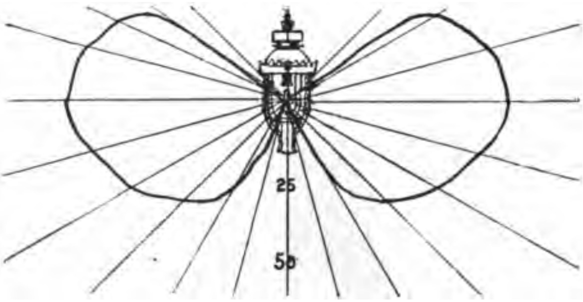

FIG. 40a.

FIG. 40–40a.—Gravity-feed gasoline street lamp.

Kerosene pressure flares of the third order.
Kerosene wick lamps of lower intensity than the third order.
Acetylene—
(*a*) With self-contained generator.

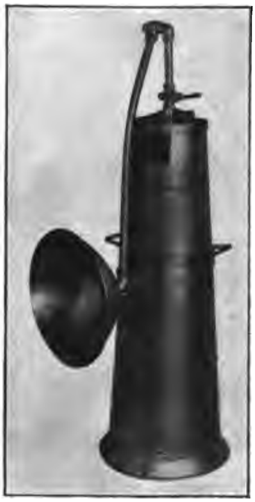

FIG. 41.—Acetylene generator flare.

(*b*) Prestolite tank.

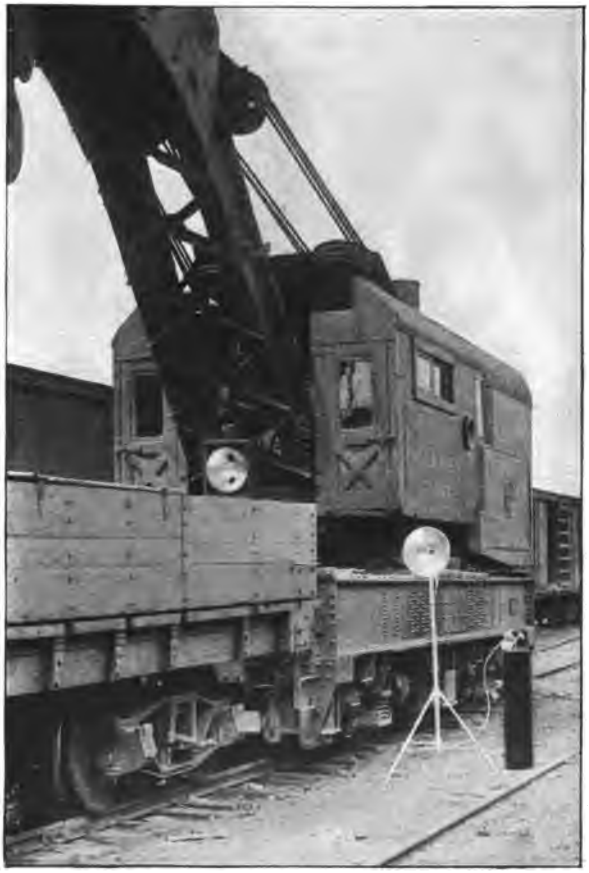

FIG. 42.—Prestolite tank flare.

Gasoline, kerosene, and acetylene should be used for exteriors only and never on piers or among piles of inflammable material.

Flare illuminants should be used for exteriors only; never on piers or among piles of inflammable material.

411. Portable self-contained units for emergency service.

These include dry-battery hand lanterns of low intensities, small prestolite tanks with burners of low intensities, and incandescent-mantle gasoline pressure-feed hand lanterns as illustrated.

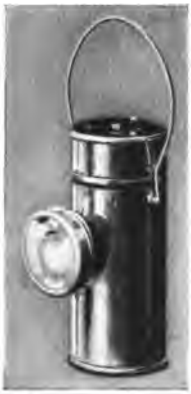
FIG. 43.—Dry battery hand lantern.

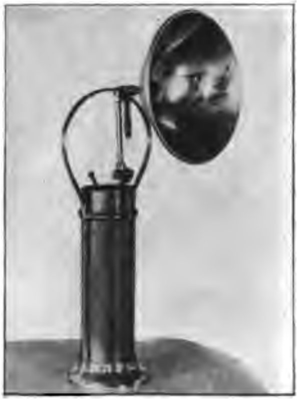
FIG. 44.—Prestolite tank lantern.

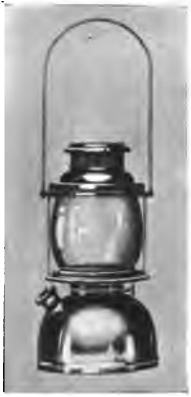
FIG. 45.—Gasoline lantern.